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ABSTRACT

This research was an attempt to produce consistent course-level placement in college mathematics based on a predicted placement score in lieu of an actual placement score. Real data were used to determine the prediction equation and a second simple random sample from the same population was used to cross-validate the results. The consequences of this practical approach to placement has direct and immediate fiscal, spatial, and time management applications. A sample of 200 students was drawn from a population of 3,200 who took a mathematics placement test during the precollege session of a university. Placement test results, subsequent course results, American College Testing (ACT) Assessment test results, and high school percentile rank were available for these students. A multiple regression equation was developed using the total score based on the number of items correct as the dependent variable and the ACT math score and high school percentile rank as independent predictors. For cross-validation purposes, a second, independent data set of 200 students was obtained. Results of the comparison between actual and prediction based placement level for either data set agreed in approximately 55% of the cases, and for the remaining cases, a more conservative placement resulted in about 18% of the cases. In about 8%, the placement level was raised. The potential benefits of this approach at a large university are discussed. An appendix contains some comparative figures from the current and proposed scoring procedures. (SLD)

Mathematics Placement Testing: Is it really necessary?

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Educational Research and Evaluation

Ohio University

Running head: PLACEMENT

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Abstract

The need to have reliable and valid mathematics placement at the post-secondary level is imperative. The ramifications to students when institutions fail to meet this need range from minor academic frustration to potential failure in the course of placement. The challenge to the institution is not limited to accurate placement but extends to *consistent* placement across time.

This research attempts to produce consistent course level placement based on a predicted placement score in lieu of an actual placement score. Real data is used to determine the prediction equation and a second simple random sample from the same population is used to cross-validate the results. The consequences of this practical approach to placement has direct and immediate fiscal, spatial, and time management applications.

Mathematics Placement Testing: Is it really necessary?

Accurate placement is the culmination of many factors. Students arrive to institutions of higher learning from a variety of secondary schools. Different schools, with individual mission statements, offer different courses and programs. A major challenge facing institutions of higher learning is to sort through the variation among students, identify the communalities, and reasonably assess the content skills for each student. Due to practical financial, spatial, and time constraints, this assessment must be both quick as well as concise. Once the decision is made to stratify students into placement levels according to estimated skill level, it is the obligation of the institution to be consistent across students as well as across time.

Unfortunately, measuring skill levels is not a simple task. Making predictions based on these measurements is even harder. Factors such as anxiety, frustration, fear, and disorientation often can and do influence test scores. Students may possess adequate skills and yet not perform well on a specific examination. Other students who do not possess the desired skills sometimes do, unfortunately, perform well. Both scenarios result in misplacement.

The desired goals of placement testing are the obtainment of accurate estimates of skills and the subsequent correct placement of students into academic levels. Each level offers a collection of mathematics courses, all homogeneous in terms of the minimal skills needed for a reasonable probability of success in the selected course. For this estimate to be reliable, the testing instrument must be reliable. This is a necessary condition, though certainly not sufficient. The testing environment, time restrictions, if any, placed on the administration of the test, and even the administration itself, all can influence the reliability of the estimate. For the resulting placement to be valid, well-defined placement criteria must be established: subsequent results must be consistently and reasonably interpretable.

The mathematics placement procedures at Ohio University are currently being assessed.

This paper attempts to offer a viable option to actual test administration. Placement, in this author's opinion, is an important advising tool. The question is not about placement per se; it is instead about placement *testing*: Is it really necessary?

A brief history

Ohio University currently requires all incoming students to take a mathematics placement test. This test is usually administered during the pre-college summer orientation, a program of which almost all traditional students partake. Tests are quickly scored and the results are readily available to facilitate Fall pre-registration, which also occurs during the pre-college session.

There are areas of concern associated with the current placement test. This instrument consists of forty 4-option multiple choice items. These items span eight content areas, allowing for five items per content area. There are four placement levels of course offerings. Depending on a students placement score, they are placed into one of the possible placement levels. The current procedure for scoring and subsequent placement is based on the number of sections 'passed'. A section (content area) is considered 'passed' if a student correctly answers at least three out of the five questions in that section. Under the current scoring/placement scheme, students with an equal number of sections passed may have very different raw score totals yet they will be placed into the same placement level. The ad hoc committee that is working on this placement issue at Ohio University agrees that a more consistent way of scoring is based on a linear, raw score total. The reader may refer to Appendices I and II for further details.

Item Analysis

An item analysis performed in July, 1997, on the current placement test (N=1,455 students) resulted in a Kuder-Richardson 21 (KR21) index of internal consistency of .855 with standard error of 2.940. The number of keyed items was forty: the mean score was 21.925, the median score was 22.00 and the range was 40. The standard deviation was reported to be 7.708 (variance 59.407).

The analysis detected one item with negative discrimination and eleven items with undesirable difficulty indices, two of which had significant p-levels, α=.05. Furthermore, the negatively discriminating item demonstrated a point biserial correlation index of -.034.

The Spearman-Brown Prophecy from KR21 indicated that in order to obtain a reliability of .90 (with items such as these), this test would need to contain sixty two items. In this analysis, the number of missing and invalid responses was 533.

For many practical reasons, the ad hoc assessment committee within the mathematics department has recommended the creation of a new testing instrument. Due to the time investment necessary to design, write, pilot, revise, and polish a new placement test, an interim method is needed. The results of this paper provide one such option.

Goals

The goal of this research is to circumvent the administration of any particular placement test by predicting a placement raw score using a method of multiple regression and then placing students into stratified placement levels accordingly. The predicted placement scores would be used in lieu of actual scores. For purposes of comparison and generalizability, it is necessary to define placement criteria (cut scores) based on a raw score index.

Resulting placement consistency will be measured with a cross-validation technique and a table of findings will be presented. More detailed tables will be provided in the appendices of this paper.

The immediate implications of this work are the savings of time, space, and staffing associated with the annual testing of (approximately) three thousand individuals.

Method

A simple random sample of 200 students[1] was drawn from a population of 3,200 students who took the math placement test during their pre-college session, summer, 1997. Information offered by the Office of Institutional Research at Ohio University, Athens, Ohio, provided the following data for every student in the sample: percent correct score per section of the placement test, subsequent course assignment, ACT composite score, ACT English score, ACT reading score, ACT science reading score, ACT math score, and high school percentile rank.

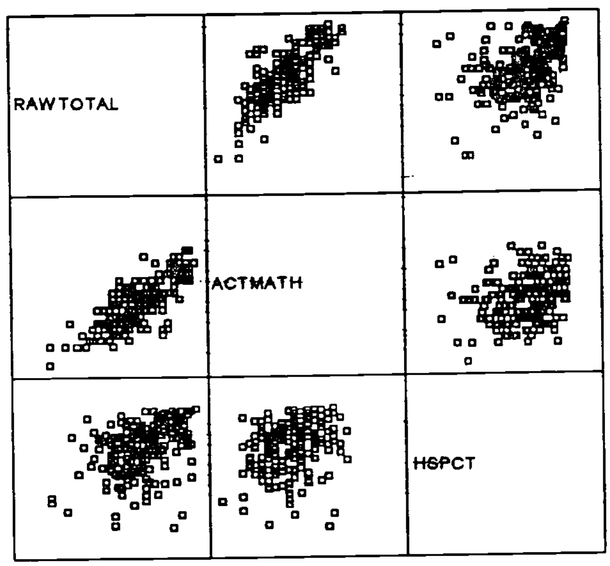
A multiple regression equation was developed using RAWTOTAL (total score based on the number of items correct) as the dependent variable and ACTMATH (ACT math score) and HSPCT (high school percentile rank) as independent predictors. Feasibility and underlying assumptions were checked as well as was the model design. A careful search for outliers and influential points was conducted.

For cross-validation purposes, a second, independent data set (N2=200) was obtained. The regression equation was applied to the second set of data and nonparametric procedures were used for comparative purposes. The results of multiple pairwise comparisons between placements based on predictions with DATA1 and DATA2 were noted. Detailed results are included in the appendix.

Assumptions:

(1) Linearity

A linearity diagnostic assessment was conducted to determine the feasibility of using a multiple regression approach.



The linear relationship between RAWTOTAL and ACTMATH is clear. In regards to a linear relationship between RAWTOTAL and HSPCT, the presence of a relative linear relationship can be argued in favor of, especially in light of the selective admissions policies in place at Ohio University and the understandable variation among high schools.

(2) Correlations:

The Pearson correlation was computed for the dependent-independent pairs of variables, as well as for the intercorrelation between the predictors.

The results can be seen in the following table:

Correlations

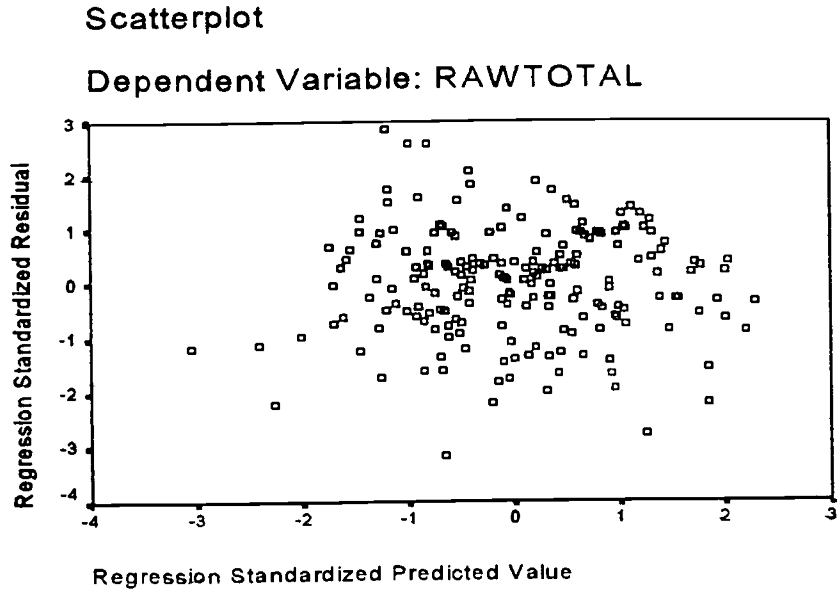
		RAWTOTAL	ACTMATH	HSPCT
Pearson Correlation	RAWTOTAL	1.000	.767**	.390**
	ACTMATH	.767**	1.000	.259**
	HSPCT	.390**	.259**	1.000
Sig. (2-tailed)	RAWTOTAL	.	.000	.000
	ACTMATH	.000	.	.000
	HSPCT	.000	.000	.
N	RAWTOTAL	200	200	200
	ACTMATH	200	200	200
	HSPCT	200	200	200

**. Correlation is significant at the 0.01 level (2-tailed).

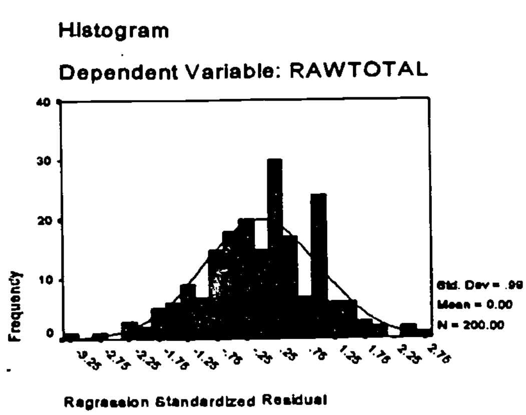
Clearly there is a strong correlation between RAWTOTAL and ACTMATH (.767) as well as a moderate correlation between RAWTOTAL and HSPCT (.390). Furthermore, the intercorrelation between the two predictor variables is relatively low (.259). Multicollinearity does not seem to be a problem at this stage of the investigation.

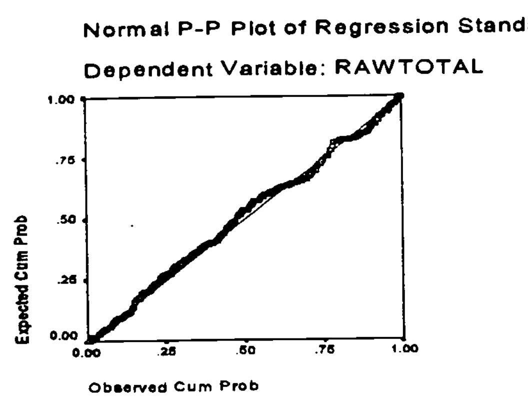
(3) Homogeneity of Variance:

As can be seen in the following scatterplot, the hypothesis of equal variances can be retained.



(4) Normality: Kolmogorov-Smirnov Tests were computed for ACTMATH, HSPCT, and RAWTOTAL. In all three cases the hypotheses of normality were retained.





The ENTER method of model selection was used. A multiple R value of .793 was obtained; R^2 = .628 and adjusted R^2 = .624. This small amount of shrinkage is an indicator of cross-validation potential . Standard error of the estimate was calculated to be 4.53. A table of coefficients follows:

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-15.020	2.163		-6.943	.000	-19.287	-10.754					
	ACTMATH	1.423	.090	.714	15.876	.000	1.246	1.599	.767	.749	.690	.933	1.072
	HSPCT	8.959E-02	.020	.205	4.557	.000	.051	.128	.390	.309	.198	.933	1.072

a. Dependent Variable: RAWTOTAL

The resulting regression equation can be written

$\hat{y}$ = -15.020 + 1.43*ACTMATH + .08959*HSPCT.

This is the regression equation that will be used on both DATA1 and DATA2 (the cross-validation sample) to calculate predicted raw scores from which placement assignments will be made.

$\hat{y}$ was calculated for every subject in DATA1 and all data were examined for outliers and influential points:

(1) Mahalanobi's Distance (D^2) was calculated and found to be 8.955.

(2) Values of Cook's distance (CD) were saved to the main data set and were carefully examined. None were found to exceed an upper bound of 1.

(3) Furthermore, outliers on Y were searched for via leverage elements. Three such points were found but none of these had CD>1 and hence, were dismissed from further scrutiny.

Based on the newly derived values of $\hat{y}$, placement levels were assigned via the following rawtotal placement criteria:

Placement level	raw score
DV1	[0,18)
PL1	[18,26)
PL2	[26,32)
PL3	[32,40]

The placement assignments for both the actual and the predicted placements were recoded into an ordinal scale for comparative purposes. Three pairwise comparisons were made on the following placements (for DATA1): actual placements based on the section-passed criteria, actual placements based on the rawtotal criteria, and predicted placements based on the rawtotal criteria. A Wilcoxon Signed Rank Test was used for all pairwise statistical comparisons.

Upon request to the Office of Institutional Research at Ohio University and of the ad-hoc committee for placement of the Department of Mathematics, a second, independent simple random sample (N2 = 200) was drawn from the same population as the original sample of this study. The regression equation was applied to the second set of data. Variable encoding is explained in the first two of the following three tables. Tables one and two have been seperated on the basis of which data set (DATA1 or DATA2) was used. This was done simply for the sake of clarity. Results of the Wilcoxon Signed Ranks Tests follow in the third table.

The reader should note that the key concept underlying the goals of this paper is consistency. Careful attention should be paid to Table 3. The pairwise comparisons between NASSIGN1->NASSIGN2 for DATA1 and NASSIGN1->NASSIGN2 for DATA2 yield practically identical results.

Variable Encoding:

Table 1: DATA1

	DATA1
ASSIGN	Actual (consistent) placement by O.U. using DATA1 and old criteria.
ASSIGN1	Actual (consistent) placement using new placement criteria and DATA1.
ASSIGN2	Predicted placement using regression1, new criteria and DATA1.

Table 2: DATA2

	DATA2
NASSIGN	Actual (consistent) placement by O.U. using DATA2 and old criteria.
NASSIGN1	Actual (consistent) placement using DATA2 and new placement criteria.
NASSIGN2	Predicted placement using regression1 and DATA2.
NASSIGN3	Predicted placement using regression2 and DATA2.

Summary:

The results of the comparison between actual and predicted-based placement level (for either data set) agreed in approximately 55% of the cases. Of the complementary 45%, recommended placement level was lowered in 18% of the cases, meaning that a more conservative placement resulted from the regression method of placement. On the other hand, in about 8% of the cases, the placement level was raised.

The same regression equation was used to calculate predicted raw scores for both (independent) sets of data (DATA1 and DATA2). Raw score placement criteria was applied in both instances. The findings described in the first paragraph therefore indicate that the placement results obtained from predicted raw scores are consistent with placement results obtained from actual testing.

What we have observed here is intuitively consistent with reality at Ohio University. Experience has shown that a few students do feel that they have been placed 'too low' and request to be reassigned to a higher placement level. It also has been observed that a moderate number of students seek supplemental instruction and tutoring services early within the Fall quarter. It is this authors opinion that a majority of the students seeking help were simply misplaced under the current placement system, and that if a method is to err in one direction or the other, it is better to err on the side on conservatism.

The potential benefits to an institution (Ohio University, in this case) are great. If implemented, the regression method of placement would end the need to use pre-college time and personnel for test administration. Test security would no longer be an issue. Neither would be test revision and maintenance. Summer personnel as well as students would have placement information prior to pre-college, allowing for students to familiarize themselves with course options prior to meeting with academic advisors. Also, the timeliness of this information would allow for adjustments in the numbers of courses offered. Actual placement would remain an option for students/parents wanting a reconsideration of suggested placement level. Hence, some type of real placement test will still need to be available for these cases as well as for many non-traditional students for whom ACT scores and/or high school percentile rank are not available.

Appendix:

I. Current Scoring Procedures:

*a passed section consists of 3/5 items correct

*there are four possible placement levels

Level	**Number of Sections Passed**	**Raw Score Range**
DV1	0,1	[0,19]
PL1	2,3,4	[6,28]
PL2	5,6,7	[15,37]
PL3	8	[24,40]

II. Recommended scoring procedure:

* Eliminate the 'sections-passes' method

Level	**Raw Score Range**
DV1	[0,18)
PL1	[18,26)
PL2	[26,32)
PL3	[32,40]

Footnotes:

[1] This information was graciously provided by the Office of Institutional Research, Ohio University, Athens, Ohio.

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